Health Consultation

BNSF Former Fueling and Maintenance Facility Skykomish, King County, Washington

June 1999

Prepared by:
Washington State Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

FOREWORD

The Washington State Department of Health (DOH) has prepared this health consultation under cooperative agreement with the Agency for Toxic Substances Disease Registry (ATSDR), an agency of the U.S. Department of Health and Human Services. The goal of the DOH and ATSDR is to identify and mitigate adverse human health effects resulting from exposure to hazardous substances in the environment. This report was prepared in accordance with methodologies and guidelines developed by ATSDR.

A health consultation provides advice on specific public health issues which may arise as a result of an actual or potential human exposure to a hazardous substance. Health consultations provide a means for DOH to respond quickly to a request for health information on hazardous substances and to make recommendations for actions to protect public health. DOH evaluates available information about hazardous substances at a site, determines whether exposures have occurred or could occur, and reports the potential harmful effects from exposure.

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BACKGROUND AND STATEMENT OF ISSUES

The Seattle-King County Department of Public Health and the Washington State Department of Ecology (Ecology) requested that the Washington State Department of Health (DOH) evaluate the results of quarterly indoor air samples collected between August 1997 and February 1999 from buildings near the Burlington Northern and Santa Fe Railroad (BNSF) Former Fueling and Maintenance Facility site for potential human health impacts. The objectives of the air sampling program were to determine if detectable concentrations of diesel fuel components (diesel/bunker C) and by-products of weathering of the diesel fuel (product) located beneath the BNSF site could result in airborne VOCs and SVOCs within the tested buildings.

The 40-acre site encompasses BNSF property and areas impacted by historical operations of the BNSF railroad fueling and maintenance facility in the town of Skykomish. The facility operated from the late 1890s until 1974. The only structures remaining at the facility are the depot and a maintenance building.

The town of Skykomish has a population of 273. The residents are served by two public water supply wells located about 1,100 feet east (upgradient) of the site.

As a result of hydrocarbon odor complaints, BNSF collected indoor air samples at a number of buildings situated above the petroleum plume. Twenty-four hour VOC and SVOC samples were collected by BNSF on an approximately quarterly basis, from August 1997 to February 1999. In addition, three mid-quarter sampling events, conducted by residents, occurred which only included VOC analysis. During the first quarter event, samples were collected from the Skykomish public school because of the its proximity to the petroleum plume and because of community concerns regarding safety of the school children, from the US Post Office due to its location on the other edge of the petroleum plume, from residence 1 due to petroleum odors in the crawl space, and from residence 2 due to health concerns and its proximity to a plume which exhibits physical and chemical characteristics that differ from other locations across the site. A third residence and a control residence were added to the sampling program beginning the second quarter, increasing the total number of sampling locations to seven.

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared a health consultation evaluating the first quarter indoor air sampling results for potential health impacts, and the DOH prepared a health consultation evaluating the second quarter indoor air sampling results for potential health impacts. ***The evaluations concluded that contaminants detected in indoor air samples were not at concentrations which would result in adverse health effects***. However, additional indoor air sampling was recommended to assess contaminant trends in order to provide a more accurate representation of exposure over time, considering the possible effects that seasonal variations (i.e.-temperature and pressure) could have on indoor air contaminant concentrations. Conclusions and recommendations from ATSDR and DOH evaluations of results of the first and second sampling quarters are presented in the health consultations for the BNSF Former Fueling and Maintenance Facility, dated December 1997 and May 1999, respectively.
This health consultation presents the findings of the last two quarter, and three mid-quarter indoor air sampling events conducted from March 1998 through February 1999.

Table 1
Maximum Indoor Air Sampling Concentrations
(March 1998-February 1999)
(all values in μg/m^3)

Volatile Organic Compounds	Screening Value	School SCH-K	School SCH-UP	Post Office PO	Residence 1 MACK	Residence 2 FREE	Residence 3 TEACH	Residence 4 CONTROL
1,1,1-trichloroethane	3,807[4]	3.8	13.8	ND	0.6	ND	ND	1.8
1,2,4-trimethylbenzene	420[5]	ND	2.09	13.3	ND	2.8	0.57	3.4
1,3,5-trimethylbenzene	420[5]	1.48	0.72	7.6	2.01	ND	ND	1.1
1,1,2-trichloroethane	0.06[1]	ND	ND	2.2	ND	ND	ND	ND
4-ethyl toluene	NA	2.27	3.38	13.4	1.18	2.7	3.3	2.9
benzene	0.1[1]	1.98	5.1	9.4	27.29	33.3	3.73	4.2
bromomethane	19[2]	ND	ND	ND	1.42	ND	ND	1.2
carbon tetrachloride	0.07[1]	0.85	1.2	1.4	1.58	1	0.72	1
chloroform	0.04[1]	0.6	ND	ND	ND	ND	0.7	ND
chloromethane	102[2]	1.5	1.7	3.3	0.6	9.4	2.8	1.7
dichloromethane (methylene chloride)	3[1]	73.5	217.4	1.4	16.2 (B)	1.3 (B)	2.1 (B)	5.8
ethylbenzene	1,000[3]	2.5	1.93	27	105.2	3.08	3.2	3
Freon 11 (trichlorofluoromethane)	320[6]	3.45	6	18.59	20.5	5.07	3	6.7
Freon 12 (dichlorodiflouoromethane)	80[6]	5.44	15.3	50.13	34.8	5.2	11.3	6.7
Freon 113	13,714[6]	1	1.1	ND	ND	ND	ND	ND
m,p-xylene	total 434[2]	6.3	7.93	152.3	471.6	10.5	15.2	10.5

Table 1 (cont.)
Maximum Indoor Air Sampling Concentrations
March 1998-February 1999
(all values in µg/m^3)

Volatile Organic Compounds (cont.)	Screening Value	School SCH-K	School SCH-UP	Post Office PO	Residence 1 MACK	Residence 2 FREE	Residence 3 TEACH	Residence 4 CONTROL
toluene	400[3]	46.08	23.9	319 (B)	1,719 (B)	58.81	9.2 (B)	30.7
trichloroethene	0.6[1]	1.1	ND	0.64	1.1	ND	3.8	ND
o-xylene	total 434[2]	2.04	2.59	91.7	183.3	3	6.4	3.4
styrene	60[2]	0.76	ND	4.9	1.32	2.8	ND	2.3
tetrachloroethene	2[1]	1.47	17.89	0.95	83.3	1.9	4.6	121.1
Total volatile organic compounds (TVOC)	NA	879	655	1,359	10,126	7,950	2,227	1,913
Semi-Volatile Organics								
1,2,4-trichlorobenzene	4.8[6]	ND	ND	0.12	0.08	0.03	NS	ND
1,2-dichlorobenzene	64[6]	ND	ND	ND	ND	ND	NS	ND
1,4-dichlorobenzene	800[3]	ND	ND	ND	ND	ND	NS	ND
1,3-dichlorobenzene	8.4[9]	0.09	0.07	0.06	0.04	ND	NS	ND
acenaphthene	0.00048[8]	ND	ND	ND	0.02	0.02	NS	0.03
bis(2-chloroisopropyl)ether	0.19[9]	ND	ND	ND	ND	ND	NS	ND
bis(2-ethylhexyl)phthalate	0.625[7]	ND	0.17	1.88	0.03	0.6	NS	0.82
diethyl phthalate	2,900[9]	0.22	0.48	0.49	0.12	0.39	NS	0.24
dimethylphthalate	17[5]	0.02	0.01	0.02	0.02	0.02	NS	0.02
di-n-butyl phthalate	NA	1.15 (B)	0.42	0.25	ND	1.29 (B)	NS	0.94 (B)
Semi-Volatile Organics (cont.)	**Screening Value**	**School SCH-K**	**School SCH-UP**	**Post Office PO**	**Residence 1 MACK**	**Residence 2 FREE**	**Residence 3 TEACH**	**Residence 4 CONTROL**
butyl benzyl phthalate	730[10]	ND	ND	ND	ND	ND	NS	ND

fluorene	0.00048[8]	ND	ND	0.02	ND	0.02	NS	ND
isophorone	8.75[7]	ND	ND	ND	ND	ND	NS	ND
naphthalene	10.5	0.13	0.19	0.35	0.38	0.21	NS	0.37
n-nitrosodiphenylamine	1.8[7]	ND	ND	ND	ND	ND	NS	1.24
phenanthrene	0.00048[8]	ND	ND	0.02	ND	0.01	NS	ND

Concentrations reported micrograms of chemical per cubic meter of air ($\mu g/m^3$)
ND = Not Detected
NA = Not Available
NS = Not Sampled
B = Compound detected in the blank sample.
Light shaded cells = contaminant concentrations exceeding a health-based screening value(s).
Darker shaded cells = the highest detected contaminant concentration.
1 = Screening value based upon EPA cancer slope factor and increased cancer risk of 1 in a million persons exposed, averaged over a lifetime
2 = Screening value based upon ATSDR chronic Minimal Risk Level.
3 = Screening value based upon EPA Reference Concentration
4 = Screening value based upon ATSDR intermediate Minimal Risk Level
5 = Screening value based upon ASIL 24-hour average Class B (non-carcinogen)
6 = Screening value based upon MTCA method B (non-carcinogen)
7 = Screening value based upon MTCA method B (carcinogen)
8 = Screening value based upon ASIL Annual Average Class A (carcinogen). "Special" PAH emission value (based on Benzo(a) pyrene)
9 = Screening value based upon EPA Region IX Preliminary Remediation Goals for Ambient Air
10 = Screening value based upon EPA Region III Preliminary Remediation Goals for Ambient Air

DISCUSSION

ATSDR has developed health-based screening values for chemicals in various media, including air, which define a concentration at or

below which carcinogenic and/or noncarcinogenic health effects are unlikely to result from exposure. Contaminant concentrations exceeding these values do not necessarily pose a health threat, but are further evaluated to determine potential health effects.

Evaluating non-cancer risk

To evaluate the potential for non-cancer health effects as a result of exposure to contaminants detected in indoor air, maximum concentrations of each contaminant detected over the past 5 sampling events were compared to ATSDR Minimal Risk Levels (MRLs) or EPA Reference Concentrations (RfCs). MRLs and RfCs are estimates of daily exposure of a human to a chemical that is likely to be without an appreciable non-cancer risk over a specified duration of exposure. They are derived from toxic effect levels obtained from human and laboratory animal studies. The toxic effect levels are expressed as either the lowest adverse effect level (LOAEL) or the no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse effect is seen, while the NOAEL is the highest dose that did not result in any adverse health effects. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

To account for uncertainty, the toxic effect levels are divided by safety factors (usually 10, 100, or 1,000) to provide the more protective MRL or RfC. If a dose exceeds the MRL or RfC, the *potential* exists for adverse health effects. Thus, a dose only slightly exceeding the MRL or RfC would fall well below the toxic effect level. The higher the estimated dose is above the MRL or RfC, the closer it will be to the toxic effect level.

Evaluating cancer risk

For screening of chemicals which are known or expected to cause cancer, it is assumed that no "safe" level exists, and EPA Inhalation Unit Risks are used to calculate an "estimated" increased cancer risk. An exposure which results in an estimated increased cancer risk of one additional cancer in a population of one million people exposed, averaged over a 70 year lifetime, is considered an acceptable risk, and is used as the screening value. In a population of one million men in the U.S., 333,000 (one in three) are expected to develop cancer from all causes in their lifetime (through 79 years of age). For U.S. woman, the figure is 200,000 (American Cancer Society Facts and Figures, 1998). The additional estimated cancer risk means that if those one million men are exposed for 30 years to this level of the chemical, 333,001 would be expected to develop cancer. For those one million woman exposed, 200,001 would be expected to develop cancer.
To evaluate the carcinogenic potential as a result of exposure to contaminants in air, average concentrations of each contaminant detected in indoor air samples over the past 7 sampling events were compared to ATSDR Cancer Risk Evaluation Guides (CREGs), if available.

One or more inhalation screening values (MRLs, RfCs, CREGs, MTCA Method B, ASILs,

and/or EPA PRGs) have been derived for 35 of the 37 detected contaminants (Table 1). Screening values for the remaining two detected contaminants (4-ethyltoluene and di-n-butylphthalate), could not be located in the literature, but were at concentrations similar to those evaluated in the two previous health consultations and found not to pose a health threat. As a result, 4-ethyltoluene and di-n-butylphthalate will not be discussed further in this health consultation.

For those 35 contaminants with inhalation screening values, the following 22 were detected below their respective screening value, so are not expected to result in adverse health effects: 1,1,1-trichloroethane; 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; bromomethane; chloromethane; ethlybenzene; Freon 11; Freon 12; Freon 113; o-xylene; styrene; 1,2,4-trichlorobenzene; 1,2-dichlorobenzene; 1,4-dichlorobenzene; 1,3-dichlorobenzene, bis(2-chloroisopropyl)ether; diethyl phthalate; dimethylphthalate; butyl benzyl phthalate; isophorone; naphthalene; and n-nitrosodiphenylamine.

Four of the 13 detected contaminants exceeding a screening value, (acenaphthene, bis(2-ethylhexyl)phthalate, fluorene, and phenanthrene) were just above their detection limits, and at levels similar to those found during previous sampling event(s) that were determined not to pose a health threat. As a result, these contaminants will not be discussed further in this health consultation.

The reader can refer to the previous health consultations for the BNSF Former Fueling and Maintenance Facility for a discussion of the following contaminants:

- 1,2-dichlorobenzene
- 1,2,4-trichlorobenzene
- 1,2,4-trimethylbenzene
- 1,3,5-trimethylbenzene
- Freon 11
- Freon 12
- acenaphthene
- phthalates
- fluorene
- n-nitrosodiphenylamine
- phenanthrene
- isophorone
- bis(2-chloroisopropyl) ether

The following nine contaminants were detected at concentrations exceeding inhalation screening values, and were further evaluated. All but one of the following nine increased in concentration at least once since the first two sampling events. Although DOH determined that the overall risk to human health remains minimal, these nine contaminants contributed the majority of that risk.

- ***1,1,2-trichloroethane***

- ***benzene***
- ***carbon tetrachloride***
- ***chloroform***
- ***dichloromethane (methylene chloride)***
- ***toluene***
- ***m,p-xylene***
- ***tetrachloroethene***
- ***trichloroethene***

CONTAMINANTS OF CONCERN EVALUATED

1,1,2-trichloroethane

1,1,2-trichloroethane exceeded a cancer screening value in 1 sample collected at the Post Office during the first mid-quarter (March 1998) sampling event. It was the only detection over the entire sampling effort. 1,1,2-trichloroethane was not detected in any product headspace samples, nor was it detected at the control location.

1,1,2-trichloroethane is a colorless, sweet-smelling liquid that is used primarily as a solvent, and as an intermediate during the manufacturing of other chemicals. Breakdown of 1,1,2-trichloroethane in air is slow; the half-life in air is about 49 days. Limited surveys have shown that 1,1,2,-trichloroethane is present in one quarter to one-half of city air samples, typically in the parts per trillion range [24]. Health effects from exposure to high oral doses have resulted in hepatocellular carcinomas and pheochromocytomas in one strain of mice. Carcinogenicity was not shown in rats. Inhalation risk estimates are based on oral exposure data. 1,1,2-Trichloroethane is structurally related to 1,2-dichloroethane, a probable human carcinogen. EPA has classified 1,1,2-trichloroethane as a class C (possible human) carcinogen.

Currently, a non-carcinogenic screening value does not exist. However, as the detection at the Post Office was much lower than the concentrations found to cause neurological effects in animal studies, ***non-cancer health effects are not expected to result from exposure***.

The estimated increased cancer risk, assuming exposure to the detected concentration (2.2µg/m^3) of 1,1,2-trichloroethane for thirty years resulted in a ***very low increased cancer risk of approximately four additional cancers in a population of one hundred thousand persons exposed***. The four-in-a-hundred thousand increased cancer risk is considered an upper bound or "worst-case" probability; the actual risk is probably less.

Benzene

Benzene was detected in indoor air from all sample locations, including the control sample location. Maximum concentrations ranged from 1.98 to 33.3 µg/m^3 over the five sample locations, and 4.2µg/m^3 at the control sample location. The maximum detected concentrations were from residences 1 and 2. Benzene was not detected in any product headspace samples.

Benzene is ubiquitous in the atmosphere. Major sources include industrial emissions, automobile service stations, exhaust from motor vehicles, and tobacco smoke. Auto exhaust and industrial emissions account for about 20% of the total nationwide exposure to benzene, and 50% of nationwide exposure to benzene results from smoking tobacco or from exposure to tobacco smoke. Benzene was detected in ambient air samples from 44 sites in 39 U.S. urban areas. The median benzene site concentrations ranged from 15 $\mu g/m^3$ to 112 $\mu g/m^3$. A median indoor air benzene concentration of 5.7 $\mu g/m^3$ was reported by the Volatile Organic Compound National Ambient Database (1975-1985). The indoor air data represent 30 cities in 16 states [5]. EPA's Office of Research and Development recently published a report summarizing eight studies conducted to measure the levels of various hazardous air pollutants, both indoors and outdoors. The reported indoor air concentrations for benzene ranged from 8 $\mu g/m^3$ to 17 $\mu g/m^3$.

ATSDR has developed noncarcinogenic screening values (Environmental Media Evaluation Guide, or EMEG) for inhalation acute (<14 days) and intermediate (15-364 days) exposures to benzene of 160 $\mu g/m^3$ and 13 $\mu g/m^3$, respectively. However, an inhalation chronic EMEG has not yet been derived. The maximum concentration of benzene (33.3 $\mu g/m^3$) detected in indoor air samples exceeded the intermediate-duration screening value. Further evaluation of noncarcinogenic effects from chronic (>365 days) exposure revealed a study that observed a no-observed-adverse-effect level (NOAEL) in humans at benzene levels of 1,722 $\mu g/m^3$. At this level, no noncarcinogenic effects were observed. The maximum concentration of benzene detected is fifty-two times lower than the NOAEL. The intermediate-duration MRL is based on a less serious LOAEL of 2,488 $\mu g/m^3$. The critical effects were an increased rapid response observed in mice in a 1992 study. The maximum concentration of benzene detected is seventy-five times lower than the LOAEL. Thus, ***short, or long-term exposure to the maximum detected benzene concentration is not anticipated to result in noncarcinogenic health effects***.

Benzene concentrations exceeded the ATSDR Cancer Risk Evaluation Guide (CREG) of 0.1 $\mu g/m^3$. Benzene is known to cause cancer of the blood forming organs (leukemia) in humans. Human leukemias associated with benzene are primarily acute myelodoid type which occurred in occupational settings that consistently had elevated levels of benzene. The estimated increased cancer risk, assuming exposure to the average benzene concentration in Residence 2 (10.1$\mu g/m^3$) for thirty years resulted ***in a very low increased cancer risk of approximately eight additional cancers in a population of one hundred thousand persons exposed***, averaged over a seventy year lifetime. The lowest cancer effect level observed in humans was twenty-nine times higher than the maximum detected concentration at Residence 2. The actual risk is likely much less as the actual exposure duration was less than 30 years.

Carbon Tetrachloride

Carbon tetrachloride was detected inconsistently at low levels in all sampling locations, including the control location. The maximum concentration was 1.58$\mu g/m^3$ at residence 1. This contaminant was not detected during the first quarter indoor air sampling event, nor was it detected in any product headspace samples.

Carbon tetrachloride is a manufactured compound, and does not occur naturally in the

environment. The compound was used in the production of refrigeration fluid and propellants for aerosol cans, as well as a pesticide, cleaning fluid and decreasing agent, and in fire extinguishers and household spot removers. With the exception of some industrial applications, the use of carbon tetrachloride was banned as it was found to cause adverse health effects. It appears that carbon tetrachloride is ubiquitous in ambient air. The average concentration of carbon tetrachloride reportedly measured in ambient air in the United States was 1.1μg/m^3, and the average values reported in four U.S. cities ranged from 0.92 to 1.8 μg/m^3 [7].

ATSDR has developed acute and intermediate duration EMEGs for carbon tetrachloride of 1,260 μg/m^3 and 315 μg/m^3, respectively. An inhalation chronic EMEG has not been derived because of a lack of toxicologic data. The maximum concentration of carbon tetrachloride (1.58μg/m^3) is well below these non-cancer screening values. Exposures of up to a year to carbon tetrachloride at concentrations found in indoor air samples are not expected to result in noncarcinogenic effects. Because studies have not been performed on effects of long-term (> 1 year) exposure of humans to low concentrations, actual human health effects from such exposures are not known. However, the maximum carbon tetrachloride concentration detected in an indoor air sample is within the average concentration range reported in the previously referenced study. ***It is unlikely that long-term exposure to the maximum concentration of carbon tetrachloride detected in indoor air would result in noncarcinogenic health effects***.

Animal studies indicate that oral exposure to carbon tetrachloride can cause liver cancer. Studies have not yet been performed to determine if inhalation of carbon tetrachloride causes tumors in animals, or whether ingestion or inhalation of carbon tetrachloride causes tumors in humans, but it should be assumed that inhalation of this contaminant could produce cancer. EPA has classified carbon tetrachloride as a probable human carcinogen. The estimated increased cancer risk, assuming continuous exposure to the maximum detected concentration (1.58μg/m^3) of carbon tetrachloride for thirty years ***may result in a very low increased cancer risk of approximately three additional cancers in a population of one hundred thousand persons exposed***, averaged over a seventy year lifetime. The three-in-a-hundred thousand increased cancer risk is an upper bound or "worst-case" probability; the actual risk is probably less than three-in-a-hundred thousand due to the less than thirty year exposure duration and lower concentrations (or non-detections) in other sampling events and residences.

Chloroform

Chloroform was detected at low concentrations in two samples; during the first mid-quarter sampling event in the kindergarten, and during the third mid-quarter sampling event in Residence 3. Chloroform was not detected in any product headspace samples, or at the control location.

Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste.

Most of the chloroform found in the environment comes from industry. Chloroform can enter the air directly from industrial releases, and by volatilizing from water and soil that contain it. One of the most significant indoor sources of chloroform is from chlorinated tap water and from showering. Typical median indoor air concentrations of chloroform range from 1μg/m^3 to 19 μg/m^3. A 1994 Canadian study noted median chloroform concentrations of 1.9 μg/m^3 [9]. The level detected in the kindergarten was below these typical background levels.

The chronic-duration inhalation MRL for chloroform is 20 ppb, and is based on a LOAEL of 2,000 ppb for hepatic effects in workers exposed to concentrations of chloroform ranging from 2,000 ppb to 205,000 ppb for 1-4 years. The maximum detection (0.7μg/m^3) chloroform detection is 143 times less than the MRL, so ***non-cancer health effects would not be expected to result from exposure***.

Although the maximum chloroform concentration slightly exceeded a carcinogenic screening value, it was within the range of typical indoor air concentrations observed in the above studies. ***The estimated increased cancer risk from exposure to the maximum detected concentration is very low; approximately one additional cancer in a population of 100,000 persons exposed, averaged over a 70 year lifetime***. Because chloroform was detected so infrequently, this risk is likely overestimated.

Dichloromethane (methylene chloride)

Dichloromethane (methylene chloride) was detected in indoor air from all sampling locations, including the control sample location. Maximum concentrations ranged from 1.4μg/m^3 to 217.4 μg/m^3 at the sample locations, and at 5.8μg/m^3 at the control sample location. Dichloromethane was detected in product headspace samples from all three locations, but was also detected in the associated method blanks.

Dichloromethane is a compound widely used as a solvent in paint strippers, as a propellant in aerosols, and as a process solvent in the manufacturing of drugs. It is also used as metal cleaning and finishing solvent. Most dichloromethane enters the environment from its use in industry and from home use of aerosols and paint removers. Mean concentrations of methylene chloride range from 0.17 μg/m^3 to 6.7 μg/m^3. Mean indoor (non-residential) concentrations of methylene chloride range from 0.2 μg/m^3 to over 1,000 μg/m^3 [16]. Health effects from exposure to very high levels in the air (> 1,000,000 μg/m^3) include loss of hearing, and vision impairment. Breathing methylene chloride also causes changes in the liver and kidney in animals, but similar effects have not been observed in humans. Studies in animals suggest that breathing methylene chloride does not cause birth defects or affect reproduction, even at high concentrations. Breathing high concentrations of methylene chloride over long periods did increase the incidence of cancer in mice.

Since even the maximum concentration of dichloromethane is well below the noncarcinogenic screening value (chronic MRL), ***non-carcinogenic health effects are unlikely from exposure to this compound***.

Dichloromethane has not been shown to cause cancer in humans exposed to concentrations in the workplace much higher than those detected in residential indoor air samples. However, studies have observed an increased incidence of cancer in mice breathing high concentrations of dichloromethane for long periods of time. As a result, EPA classifies dichloromethane as a probable human carcinogen. The estimated increased cancer risk, assuming a continuous 30 year exposure to the average concentration of 41µg/m^3 (upstairs-school) may result in ***a very low increased cancer risk of approximately two additional cancers in a population of one hundred thousand persons exposed,*** averaged over a seventy year lifetime. Because of the lower detections in most other sampling events, and the less-than 30-year exposure duration, the actual risk is likely much lower.

Toluene

Toluene was detected in indoor air from all sampling locations, including the control sample location. Maximum concentrations ranged from 9.2 (B)µg/m^3 to 1,719µg/m^3 at the sample locations, and at 30.7µg/m^3 at the control location. Toluene was also detected in product headspace samples at two of the three sample locations.

Toluene is a clear, colorless liquid with a distinctive odor. It is used as a solvent and as an additive in gasoline. Toluene is used in the manufacture of paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber. Chronic inhalation exposure to moderate to high concentrations of toluene is associated with central nervous system disturbances and impaired neuromuscular function. At lower exposure levels, subtle behavioral and neurological effects have been reported. Exposure of animals to moderate to high concentrations has caused slight adverse effects on the liver, kidneys, and lungs. Moderate to high concentrations of toluene has been shown that it can be fetotoxic and cause delays in development. Studies of workers and animals exposed to toluene generally indicate that it does not cause cancer. The EPA has determined that toluene is not classifiable as to its human carcinogenicity [21].

A single toluene detection from Residence 1 (1,719µg/m^3) exceeded the EPA Reference concentration (RfC) during the third quarter sampling event. Toluene, however, was also detected in the associated blank sample. The maximum detected concentration was forty six times lower than the LOAEL derived from a 2-year rat chronic inhalation study and sixty nine times lower than the LOAEL derived from an occupational study. The critical effects from these studies were degeneration of nasal epithelium, and neurological effects, respectively. As a result, ***adverse health effects are unlikely to result from short-term exposure to the maximum detected concentration of toluene***, especially since all other toluene detections were significantly lower than the maximum concentration evaluated.

EPA classifies toluene as a Class D compound (not classified as to carcinogenicity). This is based on no human data and inadequate animal data. Toluene did not produce positive results in the majority of genotoxic assays. As there is no quantitative carcinogenicity data, a cancer risk cannot be estimated.

M, p-xylene

There are three forms of xylene, meta-xylene, ortho-xylene, and para-xylene. These different forms are referred to as isomers, in which the methyl groups vary on the benzene ring. M,p-xylene was detected in indoor air from all sampling locations, including the control sample location. Maximum concentrations ranged from 6.3µg/m^3 to 471.6µg/m^3 at the sample locations, and at 10.5µg/m^3 at the control sample location. M,p-xylene was also detected in one of the product headspace samples.

The maximum indoor air concentration slightly exceeded the chronic duration inhalation MRL for mixed xylene. The MRL was derived from a 1993 human study which observed an increased prevalence of anxiety, forgetfulness, inability to concentrate, and other subjective symptoms. Although slightly above the MRL, the maximum concentration detected was 129 times lower than the less serious LOAEL, suggesting that exposure to the maximum detected concentration of m,p-xylene, even over a chronic duration, is ***not expected to result in adverse health effects***.

EPA classifies xylene as a Class D compound (not classifiable as to human carcinogenicity). This is based on the fact that orally administered technical xylene mixtures did not result in significant increases in incidences in tumor responses in rats or mice of both sexes. Cancer and leukemia risks among solvent-exposed workers were studied, and suggest a possible relationship between coal-based xylene exposure and leukemia. However, the study contained limitations that preclude a definitive conclusion regarding inhalation of xylene and cancer [25]. As a result, a quantitative estimate of cancer risk cannot be determined. Based upon the oral animal studies, however, ***exposure to xylene detected in indoor samples do not suggest the potential for cancer effects***.

Tetrachloroethene

Tetrachloroethene was detected at all of the sampling locations, with the highest detection at the control location. The range of maximum detections was 1.47 to 121.1µg/m^3. This contaminant was not detected during the first quarter indoor air sampling event, nor was it detected in any product headspace samples.

Tetrachloroethene is a manufactured compound widely used for dry cleaning fabrics and as a metal degreaser. It is also used to make other chemicals and some consumer products.

The maximum detection of tetrachloroethene was less than half of ATSDR's inhalation chronic EMEG. Therefore, ***long-term exposure to the maximum concentration of tetrachloroethene detected in indoor air samples is unlikely to result in noncarcinogenic health effects***.

Although some human studies (primarily epidemiology studies of dry-cleaning workers) suggest the possibility of increased cancer incidences from exposure to tetrachloroethene, especially esophageal and bladder cancers, it has not been shown to definitively cause cancer in humans.

Following inhalation exposure to tetrachloroethene, mononuclear cell leukemia was observed in rats and hepatic tumors were observed in mice. However, because both mononuclear cell leukemia and hepatic tumors are common in rats and mice, respectively, the relevance of these tumors to humans is not clear. The US Department of Health and Human Services determined that it may reasonably be anticipated to be carcinogenic to humans. In 1987, an EPA carcinogen assessment proposed tetrachloroethene as a probable human carcinogen. In light of new data, EPA reviewed findings that suggest the weight-of-evidence for tetrachloroethene as a possible human carcinogen - probable human carcinogen continuum. Presently, the agency has not adopted a final position on the classification of human carcinogenicity for this chemical [2,27].

Although EPA's inhalation unit risk is currently pending, it can be used to indicate potential increased cancer risk from tetrachloroethene exposure. At the average concentration of 61µg/m^3 (control location), ***the increased cancer risk from continuous exposure for thirty years is estimated to be very low, approximately three additional cancers in a population of one hundred thousand persons exposed***, averaged over a seventy year lifetime. Again, this is a conservative estimate representing an upper bound probability. The actual risk is probably less. With the exception of one other residence (Residence 1), tetrachloroethene was detected at much lower levels over the sampling period.

Trichloroethene

Trichloroethene (TCE) was detected in four of the seven locations sampled since the second quarter sampling event. Maximum concentrations ranged from 0.64µg/m^3 to 3.8µg/m^3 . The highest concentration exceeded the ATSDR cancer screening value. TCE was not detected at the control sample location, during the first quarter sampling event, or in any product headspace samples.

TCE is primarily used as a metal degreaser. The main users of this compound are the automotive and metals industries. It is also found in some household products, such as typewriter correction fluid, paint removers, adhesives, and spot removers.

ATSDR derived an acute MRL of 10,716µg/m^3 and an intermediate MRL of 536µg/m^3 for inhalation exposure to trichloroethene. A chronic inhalation MRL is currently not available. The maximum trichloroethene concentration found in indoor air samples is well below the noncarcinogenic screening values, indicating that ***non-carcinogenic health effects are unlikely***. The lowest NOAEL in animals observed was at 546,000µg/m^3. A human NOAEL is not currently available. The maximum concentration of TCE detected in indoor air samples is well below these MRLs and NOAELs, so non-cancer health effects are not expected.

Studies indicate that high doses of TCE in rats and mice result in tumors in the lungs, liver, and testes. Strong evidence is lacking, however, which links cancer in humans with TCE exposure. EPA classified TCE as a probable human carcinogen in 1985. However, three years later EPA reviewed information suggesting the weight-of-evidence was on a possible human carcinogen - probable human carcinogen continuum. The agency withdrew the inhalation and oral unit risk

values. EPA has yet to adopt a current position on the weight-of-evidence classification for TCE [2,22].

The pending EPA inhalation unit risk can be conservatively used to indicate potential increased cancer risk from TCE exposure. Based upon this unit risk, ***a thirty year exposure to the maximum concentration of TCE detected in an indoor air sample since the second quarter may result in a slightly increased risk of approximately six additional cancers in a population of one million persons exposed, averaged over a 70 year lifetime***. Since TCE was detected infrequently, and at lower concentrations in other sampling events, the actual risk is probably less.

1,1,1-Trichloroethane

Although 1,1,1-trichloroethane (TCA) was not detected above a non-carcinogenic screening value, the literature was reviewed to determine the potential for cancer effects. 1,1,1-TCA was found at four of the seven sampling locations since the second quarter at maximum concentrations ranging from 0.6 to 13.8 $\mu g/m^3$. A concentration of 1.8 $\mu g/m^3$ was also detected at the control sample location.

1,1,1-TCA is a manufactured compound that does not occur naturally in the environment. It has many industrial and household uses, primarily as a solvent to dissolve other substances. In industry, 1,1,1-TCA is widely used to remove oil or grease from manufactured metal parts. In homes, it may be an ingredient of products such as spot cleaners, glues and aerosol sprays. 1,1,1-TCA is also found in many building materials; new buildings can have higher indoor levels than old buildings. Since 1,1,1-TCA is used frequently in home and office products, it can be found in the indoor air at concentrations ranging from 1.6 to 23.5 $\mu g/m^3$, and in ambient air at concentrations ranging from 0.5 to 4.9 $\mu g/m^3$ [23].

Available information does not indicate that 1,1,1-TCA causes cancer in humans. EPA determined that 1,1,1-TCA is not classifiable as to its human carcinogenicity. This is based on the fact that there are no reported human data, and animal studies (one lifetime gavage, one intermediate-term inhalation) have not demonstrated carcinogenicity. Technical grade 1,1,1-TCA has been shown to be weakly mutagenic, although the contaminant, 1,4-dioxane, a known animal carcinogen, may be responsible for this response [23, 27]. ***Considering the low concentrations of 1,1,1-TCA detected in indoor air samples, it is unlikely that long-term exposure would result in cancer***.

TOTAL VOLATILE ORGANIC COMPOUNDS (TVOC's)

In addition to having analyzed air samples for specific target analytes, total volatile organic compound (TVOC) analysis was conducted. Most of the elevated TVOC detections were found in Residences 1 and 2. The average concentration of TVOCs detected in Residences 1 and 2 were 6,600 $\mu g/m^3$ and 3,528 $\mu g/m^3$, respectively. TVOC concentrations ranged from 191 $\mu g/m^3$ to 879 $\mu g/m^3$ in the school, from 423 $\mu g/m^3$ to 1,359 $\mu g/m^3$ in the Post Office, from 59 $\mu g/m^3$ to

2,227 μg/m^3 in residence 3, and from 81 μg/m^3 to 1,913 μg/m^3 in resience 4 (control residence). Maximum TVOC concentrations in air for each location sampled are presented in Table 1. All TVOC results for each location are presented in Appendix A.

Because there are no health comparison values in which to compare TVOC's, the laboratory which analyzed the samples was contacted to determine the major component(s) of the TVOCs. The lab concluded that propane contributed the majority of the TVOCs, along with the related hydrocarbons butane, ethane, and isobutane. Propane is a colorless, odorless gas, of low general toxicity. At extremely high concentrations, it is a central nervous system depressant. Health effects from exposure to very high concentrations include dizziness and disorientation. The National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have established 8-hour TWA limits of 1,800,000 μg/m^3 for propane. Although TVOC (propane) levels were elevated at Residences 1 and 2, the levels were well below those shown to result in adverse health effects in human and animal studies [19]. Levels were also between 100 and 1,000 times lower than allowable NIOSH and OSHA occupational limits described above [20].

In a 1993 study, the Indoor Environment Program began investigating indoor air quality in new houses. The concentration of TVOC in the houses ranged from 650 to 12,000 μg/m^3; the median value was 2,400 μg/m^3. A large probability-based study of existing residences by the EPA found that the median concentration of TVOC representative of a population of about 600,000 was 700 μg/m^3 [18]. The elevated levels detected in some of the samples were within the range of concentrations found in the former study, but were considerably higher than concentrations found in the latter study.

Although it is not known for sure what the specific source(s) of the TVOC's are, Residences 1 and 2 both have propane heating systems, which appear to be the likely sources of propane in indoor air at these locations. The residences were informed of this finding when it was originally encountered, and it was discussed in the previous health consultations.

CHILD HEALTH

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children deserve special emphasis with regard to exposures to environmental contaminants. Infants, young children, and the unborn may be at greater risk than adults from exposure to particular contaminants. Exposure during key periods of growth and development may lead to malformation of organs (teratogenesis), disruption of function, and even premature death. In certain instances, maternal exposure, via the placenta, could adversely effect the fetus. After birth, children may receive greater exposures to environmental contaminants than adults. Children are often more likely to be exposed to contaminants from playing outdoors, ingesting food that has come into contact with hazardous substances, or breathing soil and dust. Pound for pound body weight, children drink more water, eat more food, and breathe more air than adults. For example, in the United States, children in the first 6 months of life drink 7 times as much

water per pound as the average adult [29]. The implication for environmental health is that, by virtue of children's lower body weight, given the same exposures, they often receive significantly higher relative contaminant doses than adults.

DOH evaluated the likelihood that infants and children living in the residences tested, or that attended Skykomish public school, are being exposed to chemicals in indoor air at levels of health concern. The literature was reviewed on studies evaluating reproductive and developmental effects for the nine contaminants of concern detected in indoor air over the entire sampling period. ***Maximum detected concentrations in indoor air samples were well below those observed to result in adverse reproductive or developmental health effects for all nine contaminants of concern***.

Concentration Trends

Although there were no consistent, linear trends for a given contaminant over the 18 month sampling period, concentrations of some contaminants increased after the initial two sampling events. First quarter (8/97) sampling results showed the highest concentrations of bis(2-ethylhexyl)phthalate, di-n-butylphthalate, diethylphthalate, dimethylphthalate, butyl benzyl phthalate, fluorene, naphthalene, 1,2-dichlorobenzene, phenanthrene, and acenaphthene. Second quarter (2/98) sampling results showed the highest concentrations of trichloroethene, 1,2,4-TCB, isophorone, 1,4-dichlorobenzene, and bis(2-chloroisopropyl)ether. First mid-quarter (3/98) sampling results showed the highest concentrations of 1,2,4-TMB, 1,1,2-TCA, and Freon 113. Third quarter (5/98) sampling results showed the highest concentrations of ethylbenzene, m,p-xylene, o-xylene, toluene, 1,3,5-TMB, 4-ethyltoluene, and styrene. Second mid-quarter (8/98) sampling results showed the highest concentrations of Freon 11 and tetrachloroethene. Fourth quarter (12/98) sampling results showed the highest concentrations of benzene, bromoethane, carbon tetrachloride, Freon 12 and 1,3-dichlorobenzene. Third mid-quarter (2/99) sampling results showed the highest concentrations of chloromethane, chloroform, 1,1,1-TCA and methylene chloride.

The generally inconsistent pattern of indoor air VOC detections supports the likelihood that they are a function of either ambient background concentrations, or localized sources unrelated to the petroleum product, such as vehicle emissions, household painting products, cleaning solvents, etc. In at least one of the residences evaluated (Residence 1), significant renovation activities that occurred during most of 1998 are suspected to be the likely source of elevated VOC detections. Because of the historical (i.e. - weathered) nature of the petroleum plume underlying the area, one would not expect concentrations of VOCs and SVOCs to vary significantly, conceivably causing fluctuations in indoor air concentrations.

The control location (Residence 4) had the highest concentration of tetrachloroethene and bis(2-chloroisopropyl)ether. The control location also detected benzene, carbon tetrachloride, and methylene chloride above cancer screening values. Assuming the control location is in an area uninfluenced by the underlying petroleum plume, the most likely source(s) are from localized activities, or a function of ambient background levels, or a combination of the two. The benzene

concentration at the control location, although above a cancer screening value, is in the range of ambient background levels expected for this compound.

Comparison of Indoor Air Sample Results to Product Head Space Analysis

In order to help establish whether VOCs and SVOCs detected in indoor air samples may be related to the petroleum plume beneath BNSF property and other parts of Skykomish, BNSF collected product samples from the site from three wells; two located near residences, and one from a monitoring well that exhibited a noticeable difference in the product composition and physical characteristics at this location. The details of the product sample collection and analysis can be found in the Scope of Work and Sampling and Analysis Plan for Product Headspace Analysis and Indoor Air Sampling, prepared in October 1997. The results of the analysis were used for comparative purposes in evaluating results of the indoor air samples, and to determine if contaminants detected in indoor air could have originated from the floating petroleum product underlying the structures noted above.

Of the 37 contaminants detected in indoor air samples one or more times over the 18 month sampling period, 14 were also detected in the product headspace samples; the majority being from one of the three product sample locations (MW-39). Four SVOCs were detected in product headspace samples, but were not detected in indoor air samples. However, of the primary contaminants of concern detected in indoor air samples (1,1,2-TCA, benzene, carbon tetrachloride, chloroform, methylene chloride, xylenes, toluene, TCE, and tetrachloroethene), only toluene, xylene, and methylene chloride were detected in the product headspace samples; the latter also being detected in the associated method blank.

With the possible exception of toluene and xylenes, based on these comparisons, it would not appear that the petroleum plume underlying the area is the predominant source of the primary contaminants of concern detected in indoor air samples. However, the same cannot be said for several other VOCs and SVOCs. Specifically, 4-ethyltoluene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, acenaphthene, fluorene, and phenanthrene were detected in both indoor air samples and product headspace samples, although these compounds were detected in indoor air samples below levels of health concern.

Multiple chemical exposures

A person can be exposed by more than one pathway and to more than one chemical. Exposure to multiple pathways occurs if a contaminant is present in more than one medium (i.e., air, soil, surface water, groundwater, and sediment). For example, the dose of a contaminant received from drinking water may be combined with the dose received from contact with that same contaminant in soil.

For many chemicals, much information is available on how the individual chemical produces effects. It is much more difficult, however, to assess exposure to multiple chemicals. The vast

number of chemicals in the environment make it impossible to measure all of the possible interactions among these chemicals. In almost every situation of environmental exposure, there are multiple contaminants to consider. The potential exists for these chemicals to interact in the body and increase or decrease the potential for adverse health effects. Individual cancer risk estimates can be added since they are measures of probability. When estimating non-cancer risk, however, similarities must exist between the chemicals if the doses are to be added. Groups of chemicals that have similar toxic effects can be added, such as volatile organic compounds (VOCs) which cause liver toxicity. Polycyclic aromatic hydrocarbons (PAHs) are another group of chemicals that can be assessed as one added dose based on similarities in chemical structure and metabolites. Although some chemicals can interact to cause a toxic effect that is greater than the added effect, there is little evidence demonstrating this at concentrations commonly found in the environment.

Factors such as background exposure, a growing scientific data base, and the inherent uncertainty in assessing health risk are considered when formulating conclusions. These evaluations are based on current data and subject to change should more data become available relative to the site and/or the toxic potential of the contaminants.

Overall, our knowledge of how concurrent exposure to multiple chemicals affects the body is limited. However, given the generally inconsistent and low levels of chemicals detected in indoor air at the seven locations tested, for those compounds which might exhibit additive effects when combined, adverse health effects would not be expected.

As early as 1912, there has been evidence of petroleum seeping through the river bank into the Skykomish River from the BNSF Former Fueling and Maintenance Facility site. Exposures to related contaminants in indoor air may have occurred over a period of 80 years or more. However, without historical sampling data, reconstruction of past exposure would be extremely difficult, if not impossible. As a result, DOH was not able to evaluate whether historical exposures could have impacted public health.

The indoor air sampling events provide a picture of exposures over the 18 month sampling period only. Although exposures which may have occurred before or after this period cannot be predicted, DOH estimated the additional lifetime cancer risks, assuming long-term exposure to the average detected concentrations of individual carcinogenic contaminants for each residence over the entire 18 month sampling period.

In this health consultation, individual estimated cancer risks were added for each sampling location, using the average concentration of carcinogenic contaminants of concern over the 18 month sampling period. *These risk estimates are based on the assumption that exposure occurred continuously, for thirty years, to the average concentration of the contaminants of concern for which an inhalation unit risk is available*. As a result of these conservative assumptions, the corresponding risk estimates are also conservative. Some of the increased risk can be attributed to ambient levels of these contaminants typically found in indoor, or outdoor air, as described above. Total estimated increased cancer risk for persons exposed for 30 years

to the average concentrations of the carcinogenic contaminants of concern detected at these locations over the 18 month sampling period are as follows:

- School/Kindergarten: Total cancer risk = approximately 5 x 10^{-5}
- School/Upstairs: Total cancer risk = approximately 6 x 10^{-5}
- Post Office: Total cancer risk = 1 x 10^{-4}
- Residence 1: Total cancer risk = approximately 1 x 10^{-4}
- Residence 2: Total cancer risk = approximately 1 x 10^{-4}
- Residence 3: Total cancer risk = approximately 6.5 x 10^{-5}
- Residence 4/Control: Total cancer risk = approximately 7 x 10^{-5}

CONCLUSIONS

Based on available experimental and epidemiologic information***, exposure to contaminants detected in indoor air over the seven sampling events are not at concentrations expected to pose a health threat***. This conclusion is based upon the assumption that results of the 24-hour samples are representative of contaminant concentrations, and that the exposures are continuous for thirty years. At three of the sampling locations (both school locations and the Post Office), occupants are not normally exposed continuously, 24-hours-per-day for over a long duration. Rather, they are more likely to be exposed for less than 10 hours per day, five days per week. Under this exposure scenario, the potential for adverse health impacts is even less.

Although concentrations of some contaminants, in some samples, increased since the first two sampling events, the concentrations were not detected consistently at levels of concern. Based on the results of the 7 indoor air sampling events provided, ***DOH concludes that there is no apparent public health hazard from exposure to contaminants detected in any of the locations***. ATSDR uses the "*no apparent public health hazard*" category for sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard. Risk estimates were based on the assumption that exposures were to the average detected concentrations of contaminants of concern over the 7 sampling events.

Exposures may have occurred prior to the first indoor air sampling event in August 1997. However, without historical sampling information, assessment of these exposures was not possible. To account for past and potential future exposures, conservative exposure assumptions were used in the health consultations (continuous exposure for thirty years).

RECOMMENDATIONS

1. Adequate ventilation should be maintained indoors during renovation activities to reduce the accumulation of VOC's in indoor air.

2. Resident 1 should consider collecting an additional indoor air sample for VOCs, after

renovation activities cease, to assure levels of VOCs remain below levels of health concern.

3. Remind homeowners who have gas (propane) heating systems to check them for leaks, and to provide adequate ventilation.

4. DOH should be notified if and when future remedial actions occur, which could impact residential exposures.

FUTURE ACTIVITIES

1. DOH is available to review and evaluate future sample results, should they become available.

2. DOH can provide additional written information on specific contaminants identified during the indoor air sampling, should it be requested.

GLOSSARY

MRL: ATSDR's Minimal Risk Level. An estimate of daily human exposure to a dose of chemical that is likely to be without an appreciable risk of adverse noncancerous health effects over a specified duration of exposure. MRLs are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration via a given route of exposure. MRLs can be derived for acute, intermediate, and chronic duration exposures by the inhalation and oral routes.

CANCER SLOPE FACTOR: A plausible upperbound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upperbound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

LOAEL: Lowest Observed Adverse Effect Level. LOAEL's have been classified into "less serious" or "serious" effects. In dose-response experiments, the lowest exposure level at which there are statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

NOAEL: No Observed Adverse Effect Level. The dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be observed at this dose, but were judged not to be "adverse".

CARCINOGEN: Any substance that can cause or contribute to the production of cancer.

CONTAMINANT: Any substance or material that enters a system (the environment, human body, food, etc.) where it is not normally found.

REMEDIAL INVESTIGATION: A study designed to collect the data necessary to determine the nature and extent of contamination at a site.

COMPARISON VALUE: A concentration used to select contaminants of concern at hazardous waste sites that are further evaluated in the health assessment process. The terms comparison value and screening level are often used synonymously.

MTCA: Model Toxics Control Act. Washington State's hazardous waste cleanup law.

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APPENDIX A

INDOOR AIR SAMPLING RESULTS FOR EACH LOCATION BY SAMPLING QUARTER

(Values are in micrograms per cubic meter ($\mu g/m^3$)

SCHOOL-K (Basement)							
VOCs	1st Qtr (8/97)	2nd Qtr (2/98)	1st mid-Qtr (3/98)	3rd Qtr (5/98)	2nd mid-Qtr (8/98)	4th Qtr (12/98)	3rd mid-Qtr (2/99)
1,1,1-trichloroethane		2.2			3.8	1.37	2.4
1,2,4-trimethylbenzene	2.8	4.7					
1,3,5-trimethylbenzene	ND	1.7				1.48	
1,1,2-TCA							
4-ethyl toluene	2.7	2.4				2.27	
benzene	ND	2.6	1.3		1.2	1.98	1.6
bromomethane							
carbon tetrachloride		0.8				0.85	

chloroform			0.6				
chloromethane	ND	1.3	1.5	0.7	1.2	0.51	
dichloromethane (methylene chloride)	7.2 (B)	7.2	7.5 (B)	4.4 (B)		12.34	73.5
ethylbenzene	3.1	1.4		2.5		1.45	
Freon 11 (trichlorofluoromethane)	ND	2.2	2.6	2.3	2.3	3.45	2.3
Freon 12 (dichlorodiflouoromethane)	ND	4.2	4.3	5.2	4	5.44	3.4
Freon 113			1				
Freon 114							
m,p-xylene	11.9	5.2	0.9	6.3		5.87	1.9
o-xylene	2.9	2		1.4		2.04	
styrene						0.76	
tetrachloroethene		3.7	1			1.47	
toluene	8.9	62.2	12.2	10.2 (B)	1.7 (B)	46.08	4.4
trichloroethene		0.7	1.1				
Total VOCs	NA	700	306	191	207	879	279

SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene	ND/0.04*		NA		NA		NA
1,2-dichlorobenzene			NA		NA		NA
1,4-dichlorobenzene	2.2/8.7*	0.9/0.42	NA		NA		NA
1,3-dichlorobenzene			NA		NA	0.09	NA
acenaphthene	0.02/0.02		NA		NA		NA
bis(2-chloroisopropyl)ether			NA		NA		NA
bis(2-ethylhexyl)phthalate	0.7/2.4	0.189	NA		NA		NA
diethyl phthalate	0.3/0.4	0.063	NA		NA	0.22	NA

dimethylphthalate	ND/0.03		NA		NA	0.02	NA
di-n-butyl phthalate	2.2/2.7	0.274 (B)	NA	1.15 (B)	NA	0.21	NA
butyl benzyl phthalate	0.08/ND		NA		NA		NA
fluorene	ND/ND		NA		NA		NA
isophorone			NA		NA		NA
naphthalene	0.2/0.2	0.147 (B)	NA		NA	0.13	NA
n-nitrosodiphenylamine	ND/ND		NA		NA		NA
phenanthrene	0.03/0.04		NA		NA		NA

* = 1st number is main floor/2nd number is basement

SCHOOL-UP (Main Floor)							
VOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,1,1-trichloroethane		2	0.9	3.5	0.6	11.69	13.8
1,2,4-trimethylbenzene	2.8	4.8	1.2			2.09	
1,3,5-trimethylbenzene		1.7				0.72	
1,1,2-TCA							
4-ethyl toluene	2.7	2.5	1.1 (Q)			3.38	2.6
benzene		3.6	1.8	1.3	1.2	3.01	5.1
bromomethane							

carbon tetrachloride			0.7 (Q)		1.2	0.75	
chloroform							
chloromethane		2.3	1.7	1.3	1.7		
dichloromethane (methylene chloride)	7.2 (B)	6.2	4 (B)	12 (B)	1 (B)	4.21	217.4
ethylbenzene	3.1	1.5	0.9		0.6	1.93	1.2
Freon 11 (trichlorofluoromethane)		2.3	2.2	6	1.9	2.37	1.9
Freon 12 (dichlorodiflouoromethane)		4.7	5.8	15.3	4	5.86	4
Freon 113			1.1				
Freon 114							
m,p-xylene	11.9	5.4	2.9		0.9 (B)	7.93	6.6
o-xylene	2.9	2.1	1			2.59	
styrene							
tetrachloroethene		1.2			1.4	17.89	
toluene	8.9	28.4	4.9	16.5 (B)	4.7	23.9	19.1
trichloroethene							
Total VOCs	422	599	387	438	328	655	415

SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene		0.073	NA	ND	NA		NA
1,2-dichlorobenzene			NA	ND	NA		NA
1,4-dichlorobenzene	2.2	0.71	NA	ND	NA		NA
1,3-dichlorobenzene			NA	ND	NA	0.07	NA
acenaphthene	0.02	0.015	NA	ND	NA		NA
bis(2-chloroisopropyl)ether			NA	ND	NA		NA
bis(2-ethylhexyl)phthalate	0.7	0.71	NA	ND	NA	0.17	NA
diethyl phthalate	0.3	0.235	NA	ND	NA	0.48	NA

dimethylphthalate			NA	ND	NA	0.01	NA
di-n-butyl phthalate	2.2	0.678 (B)	NA	ND	NA	0.42	NA
butyl benzyl phthalate	0.08		NA	ND	NA		NA
fluorene			NA	ND	NA		NA
isophorone			NA	ND	NA		NA
naphthalene	0.2	0.417 (B)	NA	ND	NA	0.19	NA
n-nitrosodiphenylamine		0.063	NA	ND	NA		NA
phenanthrene	0.03	0.015	NA	ND	NA		NA

POST OFFICE							
VOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,1,1-trichloroethane							
1,2,4-trimethylbenzene	9.9	8	13.3	12.8		1.1	3.4
1,3,5-trimethylbenzene	4.9	3	4.5	7.6			1
1,1,2-TCA			2.2				
4-ethyl toluene	8.2	3.8	5.3	13.4		1.34	4
benzene	3	5.1	9.4	2.2	1.7	2.85	5.6

bromomethane							
carbon tetrachloride					1.4	0.85	
chloroform							
chloromethane	1.2	1.8		3.3	0.3		0.6
dichloromethane (methylene chloride)	2.8 (B)	2.3	1.4	1.1 (B)	0.8		
ethylbenzene	8.9	3.9	5.2	27		1.7	2.6
Freon 11 (trichlorofluoromethane)	12	9.5	14	15.8	9.2	18.59	7.4
Freon 12 (dichlorodiflouoromethane)	2.8	4.9	3	5.6	4.5	50.13	2.6
Freon 113							
Freon 114							
m,p-xylene	34.9	13.9	22	152.3		5.24	10.8
o-xylene	11.1	5	7.1	91.7		1.89	2.9
styrene				4.9		0.77	
tetrachloroethene						0.95	
toluene	119	162.5	155.5	319 (B)	28.9 (B)	31.8	182.8
trichloroethene						0.64	
Total VOCs	921	764	1,359	1,156	423	1,308	901

SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene	0.03	0.083	NA	ND	NA	0.12	NA
1,2-dichlorobenzene			NA	ND	NA		NA
1,4-dichlorobenzene	0.06	0.054	NA	ND	NA		NA
1,3-dichlorobenzene			NA	ND	NA	0.06	NA
acenaphthene	0.03	0.025	NA	ND	NA		NA
bis(2-chloroisopropyl)ether			NA	ND	NA		NA
bis(2-ethylhexyl)phthalate	2	0.8	NA	ND	NA	1.88	NA

diethyl phthalate	0.9	0.184	NA	ND	NA	0.49	NA
dimethylphthalate	0.4		NA	ND	NA	0.02	NA
di-n-butyl phthalate	1.9	0.839 (B)	NA	0.65 (B)	NA	0.25	NA
butyl benzyl phthalate	0.08		NA	ND	NA		NA
fluorene	0.04	0.017	NA	ND	NA	0.02	NA
isophorone		0.083	NA	ND	NA		NA
naphthalene	0.7	0.587 (B)	NA	ND	NA	0.35	NA
n-nitrosodiphenylamine	0.05	0.15	NA	ND	NA		NA
phenanthrene	0.05	0.014	NA	ND	NA	0.02	NA

RESIDENCE 1							
VOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,1,1-trichloroethane	ND	4.3	NA	ND	0.6	ND	ND
1,2,4-trimethylbenzene	2.8	0.6	NA	ND	ND	ND	ND
1,3,5-trimethylbenzene	ND	ND	NA	ND	ND	2.01	ND
1,1,2-TCA	ND		NA	ND	ND	ND	ND
4-ethyl toluene	2 (Q)	0.8	NA	ND	ND	1.18	ND
benzene	1.2	2.5	NA	ND	1.1	27.29	ND
bromomethane	ND		NA	ND	ND	1.42	ND

carbon tetrachloride	ND	ND	NA	ND	ND	1.58	ND
chloroform	ND		NA	ND	ND	ND	ND
chloromethane	0.7 (Q)	6.3	NA	ND	0.6	ND	ND
dichloromethane (methylene chloride)	1.7 (B)	16.1 (Q)	NA	16.2 (B)	2.5	11.11	ND
ethylbenzene	2.3	2.5	NA	105.2	ND	3.5	ND
Freon 11 (trichlorofluoromethane)	9.3	6.9	NA	ND	20.5	8.38	4.3
Freon 12 (dichlorodiflouoromethane)	2.4	5	NA	ND	34.8	3.98	1.5
Freon 113	ND		NA	ND	ND	ND	ND
Freon 114			NA		12.3	ND	ND
m,p-xylene	10.6	4.7	NA	471.6	ND	13.9	ND
o-xylene	4	1.3	NA	183.3	ND	4.29	ND
styrene	ND	1.1	NA	ND	ND	1.32	ND
tetrachloroethene	ND	2.9	NA	ND	83.3	0.95	ND
toluene	11	146.9	NA	1,719 (B)	14.3	125	0.7
trichloroethene	ND	19.4	NA	ND	1.1	ND	ND
ethane		148					
propane		37					
isobutane		210					
n-butane		3					
Total VOCs		4,239		8,821	1,287	8,537	10,126
SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene	1.2	0.217/0.275	NA	ND	NA	0.08	NA
1,2-dichlorobenzene	0.02		NA	ND	NA	ND	NA
1,4-dichlorobenzene	0.2	ND/ND	NA	ND	NA	ND	NA
1,3-dichlorobenzene	ND		NA	ND	NA	0.04	NA
acenaphthene	0.08	0.023/0.023	NA	ND	NA	0.02	NA
bis(2-chloroisopropyl)ether	ND	ND	NA	ND	NA	ND	NA
bis(2-ethylhexyl)phthalate	1.1	1.256/0.75	NA	ND	NA	0.03	NA
diethyl phthalate	0.6	0.101/0.103	NA	ND	NA	0.12	NA
dimethylphthalate	0.05	ND/ND	NA	ND	NA	0.02	NA

di-n-butyl phthalate	2.5	0.291(B)/0.305(B)	NA	ND	NA	ND	NA
butyl benzyl phthalate	0.06	ND/ND	NA	ND	NA	ND	NA
fluorene	0.04	ND/ND	NA	ND	NA	ND	NA
isophorone	ND	ND/ND	NA	ND	NA	ND	NA
naphthalene	0.9	0.725 (B)/0.739 (B)	NA	ND	NA	0.38	NA
n-nitrosodiphenylamine	ND	ND/ND	NA	ND	NA	ND	NA
phenanthrene	0.04	ND/ND	NA	ND	NA	ND	NA

RESIDENCE 2							
VOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,1,1-trichloroethane	ND	0.9	ND	ND	ND	ND	ND
1,2,4-trimethylbenzene	ND	0.9	ND	2.8	ND	1.53	ND
1,3,5-trimethylbenzene	ND	ND	ND	ND	ND	ND	ND
1,1,2-TCA	ND	ND	ND	ND	ND	ND	ND
4-ethyl toluene	ND	ND	ND	1.4	ND	2.7	2.5
benzene	ND	5	6	1.1	1.7	33.3	13.6
bromomethane	ND	ND	ND	ND	ND	ND	ND
carbon tetrachloride	ND	ND	ND	ND	1	ND	1
chloroform	ND	ND	ND	ND	ND	ND	ND

chloromethane	8.3 (Q)	5.4	ND	1.1	2.5	3.6	9.4
dichloromethane (methylene chloride)	8.1 (B)	0.8	ND	1.3 (B)	ND	ND	ND
ethylbenzene	ND	1.3	1.7	ND	ND	3.08	2
Freon 11 (trichlorofluoromethane)	ND	4.9	4.4	2.2	3.2	5.07	6
Freon 12 (dichlorodiflouoromethane)	ND	3	1.9	4.2	4.6	2.94	5.2
Freon 113	ND	ND	ND	ND	ND	ND	ND
m,p-xylene	11.6	4.4	6.3	1.8	ND	10.5	8
o-xylene	ND	1.3	1.5	ND	ND	3	1.4
styrene	ND	ND	2.2	ND	ND	2.24	2.8
tetrachloroethene	ND	ND	1.9	ND	ND	ND	ND
toluene	27.2	51.4	21.3	4.4 (B)	2.5	58.81	30.7
trichloroethene	ND	ND	ND	ND	ND	ND	ND
ethane		19					
propane		1,230					
isobutane		430					
n-butane		6					
Total VOCs	2,011	3,980	3,250	269	1,148	6,089	7,950

SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene	ND	ND	NA	ND	NA	0.03	NA
1,2-dichlorobenzene	ND	ND	NA	ND	NA	ND	NA
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-dichlorobenzene	ND	ND	NA	ND	NA	ND	NA
acenaphthene	0.02	0.024	NA	ND	NA	0.02	NA
bis(2-chloroisopropyl)ether	ND	0.432	NA	ND	NA	ND	NA
bis(2-ethylhexyl)phthalate	3.4	0.51	NA	0.6	NA	0.04	NA
diethyl phthalate	0.3	0.273	NA	ND	NA	0.39	NA
dimethylphthalate	0.02	ND	NA	ND	NA	0.02	NA
di-n-butyl phthalate	1.1	0.879 (B)	NA	1.29 (B)	NA	0.33	NA

butyl benzyl phthalate	ND	ND	NA	ND	NA	ND	NA
fluorene	ND	0.017	NA	ND	NA	0.02	NA
isophorone	ND	ND	NA	ND	NA	ND	NA
naphthalene	0.2	0.351 (B)	NA	ND	NA	0.21	NA
n-nitrosodiphenylamine	ND	0.11	NA	ND	NA	ND	NA
phenanthrene	0.02	0.02	NA	ND	NA	0.01	NA

RESIDENCE 3 (TEACHER)							
VOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,1,1-trichloroethane	NA	2.6					
1,2,4-trimethylbenzene	NA	3.6				0.57	
1,3,5-trimethylbenzene	NA	1.3					
1,1,2-TCA	NA						
4-ethyl toluene	NA	1.8		3.3		0.99	
benzene	NA	2.8	1.1		1.4	3.73	1.2
bromomethane	NA						
carbon tetrachloride	NA	0.7				0.72	
chloroform	NA						0.7
chloromethane	NA	6.3	1.6		2.8	1.26	

dichloromethane (methylene chloride)	NA	14.2	1.7 (B)	2.1 (B)	1	0.76	
ethylbenzene	NA	4.8		3.2		0.67	
Freon 11 (trichlorofluoromethane)	NA	2.3	2		3	1.2	0.8
Freon 12 (dichlorodiflouoromethane)	NA	13	4.1	2.6	11.3	2.9	5.3
Freon 113	NA						
Freon 114	NA						
m,p-xylene	NA	13.3	1	15.2		2.45	1.4
o-xylene	NA	5.5		6.4		0.72	
styrene	NA						
tetrachloroethene	NA	3.2		4.6			
toluene	NA	166	2.3	9.2 (B)	3.8 (B)	8.25	3.2
trichloroethene	NA	21.4			3.8	0.69	
ethane	NA	24					
propane	NA	145					
isobutane	NA	295					
n-butane	NA	2					
Total VOCs	NA	2,227	59	695	144	456	115
SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene	NA	NS	NA		NA		NA
1,2-dichlorobenzene	NA	NS	NA		NA		NA
1,4-dichlorobenzene	NA	NS	NA		NA		NA
1,3-dichlorobenzene	NA	NS	NA		NA		NA
acenaphthene	NA	NS	NA		NA		NA
bis(2-chloroisopropyl)ether	NA	NS	NA		NA		NA
bis(2-ethylhexyl)phthalate	NA	NS	NA		NA		NA
diethyl phthalate	NA	NS	NA		NA		NA
dimethylphthalate	NA	NS	NA		NA		NA
di-n-butyl phthalate	NA	NS	NA		NA		NA
butyl benzyl phthalate	NA	NS	NA		NA		NA
fluorene	NA	NS	NA		NA		NA

SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
isophorone	NA	NS	NA		NA		NA
naphthalene	NA	NS	NA		NA		NA
n-nitrosodiphenylamine	NA	NS	NA		NA		NA
phenanthrene	NA	NS	NA		NA		NA

RESIDENCE 4 (CONTROL)							
VOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,1,1-trichloroethane	NA	0.9		1.8	1.7		
1,2,4-trimethylbenzene	NA			3.4			
1,3,5-trimethylbenzene	NA			1.1			
1,1,2-TCA	NA						
4-ethyl toluene	NA			2.5	2.9		
benzene	NA	2.7	1	4.2	3.1	3.44	1
bromomethane	NA		1.2				
carbon tetrachloride	NA			1		0.66	
chloroform	NA						
chloromethane	NA	19.1	0.8	1.7	1	0.7	0.4

dichloromethane (methylene chloride)	NA	1.1 (Q)	1.2	1 (B)	5.8		
ethylbenzene	NA	0.8		3	1.4		
Freon 11 (trichlorofluoromethane)	NA	2.8	3.4	6.7	5.5	1.48	1
Freon 12 (dichlorodiflouoromethane)	NA	3.6	2.2	1.7	6.7	3.21	3.9
Freon 113	NA						
Freon 114	NA						
m,p-xylene	NA	2.7	1.5	10.5	4.7	1.4	
o-xylene	NA	1.2		3.4		0.48	
styrene	NA			2.3			
tetrachloroethene	NA				121.1	1.32	
toluene	NA	22.1	6.4	30.7	25.3	8.93	1.7
trichloroethene	NA						
ethane	NA	18					
propane	NA	424					
isobutane	NA	10					
n-butane	NA	< 5.6					
Total VOCs	NA	1,913	952	128	144	199	81
SVOCs	8/97	2/98	3/98	5/98	8/98	12/98	2/99
1,2,4-trichlorobenzene	NA	0.059	NA		NA		NA
1,2-dichlorobenzene	NA		NA		NA		NA
1,4-dichlorobenzene	NA	0.118	NA		NA		NA
1,3-dichlorobenzene	NA		NA		NA		NA
acenaphthene	NA	0.019	NA		NA	0.03	NA
bis(2-chloroisopropyl)ether	NA	0.72	NA		NA		NA
bis(2-ethylhexyl)phthalate	NA	0.86	NA	0.82	NA	0.07	NA
diethyl phthalate	NA	0.209	NA		NA	0.24	NA
dimethylphthalate	NA		NA		NA	0.02	NA
di-n-butyl phthalate	NA	0.75 (B)	NA	0.94 (B)	NA	0.32	NA
butyl benzyl phthalate	NA		NA		NA		NA
fluorene	NA		NA		NA		NA

isophorone	NA		NA		NA		NA
naphthalene	NA	0.331 (B)	NA		NA	0.37	NA
n-nitrosodiphenylamine	NA	0.03	NA	1.24	NA		NA
phenanthrene	NA		NA		NA		NA